CRJ-700 Alerting Issues – Traffic conflict

1. Initiating Condition: TCAS resolution advisory

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Red "traffic" warning flashing on PFD between HSI and VSI	Proximity detected by TCAS at RA threshold. Intruding aircraft is within 30 sec from closest point of approach	The intruder aircraft climb or descending arrow will only be present when detected value is >500 fpm	System knows configuration of aircraft and will take this into account when determining best choice of RA. However, does not notice abnormal aircraft operations such as single engine operations.	RA automatically suppressed by higher order warnings (e.g., stall, windshear, terrain) and in certain altitude regimes; pilots must manually suppress RA in certain conditions, e.g., closely spaced parallel approaches and engine failures; Increase descent RAs inhibited below 1450 ft. AGL; Descent RAhs inhibited below 1000 ft. AGL; All RAs inhibited below 500 ft. AGL	TCAS removes visual alerts/cues and annunciates clear of conflict (aural)
	Red and green bands, pointer and rate on VSI showing needed climb or decent to comply with TCAS RA		In some cases, can be difficult to see a green band when it is narrow and in the moment			
	Target symbology on TCAS or MFD screen shows trend information and altitude		Potential confusion in RA display between up/down arrow symbology and +/- symbology			
Aural Alerts	ATC Traffic Alert	Proximity detected by ATC radar/ conflict alert at system's threshold	Pilot has to hear, comprehend, and react to verbally transmitted information from TCAS			

CRJ-700 Alerting Issues – Traffic conflict

1. Initiating Condition: TCAS resolution advisory – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Aural Alerts	"Traffic, traffic" aural	Proximity detected by TCAS at TA threshold. Intruding aircraft is within 30 sec from closest point of approach	Pilot has to hear, comprehend, and react to verbally transmitted information from TCAS			
Tactile Alerts	None					
Visual Cues	Red square and data tag on MFD showing exact bearing, altitude (relative or absolute as selected by pilot) and climb or descent for intruder aircraft. Can be displayed on both navigation and TCAS screens	Proximity detected by TCAS at RA threshold. Intruding aircraft is within 30 sec from closest point of approach				
	Visual contact with traffic					
Aural Cues	None					
Tactile/ Somatic Cues	None					

Expected Pilot Response(s)

- The system is designed with the expectation that the pilot will respond within 5 seconds.
- Maneuver vertically in response to TCAS RA directives
- Prioritize TCAS RA information over ATC and visual detection information
- Maneuver vertically and/or laterally as prompted by visual closure rate and direction of movement
- In the case of a corrective RA (e.g. a reversal) the system is designed to expect a pilot response within 2.5 seconds
- Pilot is expected to maintain the requested climb/descent until the aural "clear of conflict" is heard
- Report TCAS RA to ATC as soon as possible
- Caution for endangering passengers with unnecessarily abrupt compliance maneuvers

CRJ-700 Alerting Issues – Traffic conflict

1. Initiating Condition: TCAS resolution advisory – Cont.

Possible sources of confusion with regard to pilot response(s)

- RA directives may conflict with ATC directives, so pilots need to react in accordance with TCAS RA despite receiving conflicting instructions. True for PRM approaches and when talking to break-out maneuvers
- RA directives may conflict with ATC directives, so pilots need to ignore habituated response to ATC
- RA directives may conflict with visual detection of traffic conflict, so pilots need to react in accordance with TCAS RA despite receiving conflicting visual information
- There are 12 different aural commands that can be issued. Many of which are rarely heard and have been confused by pilots as to the expected response
- Pilot focusing intently on the VSI and climb/descent requirements that thrust/airspeed is not effectively managed
- Failure to disconnect the AP when starting to comply with TCAS RA
- Lateral evasive maneuvers are not to be accomplished utilizing display on MFD. Only when in visual contact should lateral changes be accomplished.
- When no valid bearing information is received by TCAS. No traffic symbol will be shown and the pilot has to go to the TCAS page on the MFD to review the "no bearing table"
- TCAS does not respond to aircraft that are not equipped with a transponder
- Pilots should use caution that any aircraft seen visually may not be the intruder aircraft that triggered the RA

How does pilot know condition is resolved/recovered?

- Aural "clear of conflict" will be annunciated
- Red traffic indication between HSI and VSI will extinguish
- Red-boxed traffic squares turn amber and/or diverge from own aircraft position
- Visual detection/evaluation of divergence from previous closure rate

Issues with regard to multiple concurrent non-normal conditions

- When TCAS RA is accompanied by a GPWS or STALL warning, RA compliance is to be discontinued

CRJ-700 Alerting Issues – Traffic conflict

2. Initiating Condition: Traffic conflict in Next-Gen ATM environment (ground-based sequencing/metering error or datacom error)

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	ADS-In RA vertical guidance on PFD/EADI	Proximity detected by ATM system and/or CDTI (TCAS-like) processing at RA threshold		Future alert/cue designs may differ from current TCAS designs.		
Aural Alerts	ATM Traffic Alert	Proximity detected by ATM system at RA threshold				
	ADS-In RA aural warning	Proximity detected by ATM system and/or CDTI (TCAS-like) processing at RA threshold				
Tactile Alerts	None	None				
Visual Cues	ADS CDTI with conflict display on EHSI/ND	CDTI conflict display system threshold				
	Visual contact with traffic	Human visual search, detection, selective attention, personal subjective evaluation (N.B., closer traffic tolerances under Next-Gen)	Pilot evaluation of detected visual traffic can be misleading as to projected proximity and/or possibly mistaking one threat aircraft for another		Visual traffic cues can be masked by weather and aircraft structure	
Aural Cues	None					
Tactile/ Somatic Cues	None					

CRJ-700 Alerting Issues – Traffic conflict

2. Initiating Condition: Traffic conflict in Next-Gen ATM environment (ground-based sequencing/metering error or datacom error) – Cont.

Expected Pilot Response(s)

- Maneuver the aircraft vertically and/or laterally as directed by ADS-In and CDTI systems
- If aircraft response is automated, evaluate the validity of the ADS-In and CDTI alerts and monitor the aircraft response
- If response is manual, execute the response within established next-gen collision avoidance system specifications.

Possible sources of confusion with regard to pilot response(s)

- Tolerances will be so close under Next-Gen that the ability of pilots to evaluate and respond to traffic conflicts will be limited, and as well, pilot ability to detect and respond to invalid alerts and automated aircraft responses will be limited.
- RA directives may conflict with automated or human ATC directives, which may be a very rare event due to Next-Gen system reliability (issue: automation dependency). Depending on future display and communications designs for Next-Gen, pilots may not have complete situational awareness of their aircraft's automated trajectory and its relationship to the traffic conflict.

Issues with regard to multiple concurrent non-normal conditions

- Cascading effects of RA response on Next-Gen traffic separation and metering